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Food consumption by the larvae of *Sericostoma vittatum* (Trichoptera), an endemic species from the Iberian Peninsula

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Abstract

The caddisfly *Sericostoma vittatum* Rambur (Trichoptera: Sericostomatidae) is an endemic species of the Iberian Peninsula. Under laboratory conditions, larvae of *S. vittatum* had a higher activity and metabolism during the night. Besides consuming particulate allochthonous organic matter, young stages are also able to feed and grow on faecal pellets from adults. Daily growth rates varied from 0.02 mg (0.8–3.7 mg size class animals) to 0.31 mg dry mass (10.6–22.8 mg size class animals). Due to the high densities of this species (annual mean of 25 individuals m^{-2}; maximum of 96 individuals m^{-2}) and high consumption rates (0.47 mg leaf dry mass mg $animal^{-1}$ $d^{-1}$for small larvae), this species has a potential key role on the fragmentation of allochthonous organic matter of streams in central Portugal.

Introduction

In small woodland streams, a major energy source is allochthonous organic material, such as leaves, berries or twigs that fall in the water and enter then in a decomposition process (Triska et al., 1982). Decomposition is a continuous process involving an initial fast mass loss due to leaching (Barlöcher, 1991) microbial colonisation and attack, and finally mechanical and invertebrate (biological) fragmentation (Webster & Benfield, 1986; Gessner et al., 1999).

Biological fragmentation occurs due to feeding activities of 'shredders', a trophic group of consumers that includes immature stages of several insects such as trichoptera and plecoptera (Andersen & Cargill, 1987). These invertebrates may be very abundant in small tree lined brooks and, therefore, play an important role in organic matter fragmentation, converting the coarse organic matter (CPOM) into animal biomass and fine particulate organic matter (Cummins, 1973). The caddisfly *Sericostoma personatum* is a shredder with a widespread distribution thought Europe (Elliot, 1969; Iversen, 1974, 1979, 1980; Frieberg & Jacobsen, 1994). However, it does not occur in the Iberian Peninsula (Illies, 1978). In Serra da Lousã, Central Portugal, the Iberian endemic caddisfly *Sericostoma vittatum* seems to fill the ecological niche of *Sericostoma personatum*. This species occurs all year around, is the most abundant and conspicuous consumer in some local streams (e.g. Ribeira de S João; pers. obs. and unpublished data) and feeds on conditioned leaves (Feio & Graça, 1997). However, little information has been published on the trophic ecology of the larvae of this species. The aim of this research was to contribute to the knowledge of the biology of this species, specifically on its metabolism, activity and growth conditions.

Materials and methods

Animals and leaves

Specimens of *Sericostoma vittatum* were collected along the year 1996 from Ribeira de S. João, Serra da Lousã, Central Portugal, using a hand net. The invertebrates were collected near the banks in areas where leaves were accumulated. They were kept in

laboratory, at least for 1 week before the experiments in boxes with filtered (GF/C Whatman) stream water, aerated and with stream sand in the bottom (grain size ≈1 mm). The sand was collected from the stream and ignited for 1.5 h at 500 °C. The standard boxes were plastic containers 9.5 cm high, and 14 × 19.5 cm of basal area, filled with 5 cm of water. All experiments were carried out in a room where the temperature was set to 15 °C and a Light-Dark photoperiod of 12/12 h.

The food supplied to *Sericostoma vittatum* larvae were leaves of *Castanea sativa*, a common tree species in the basin. Decomposition rates of k=0.008 d^{-1} (Canhoto, 1994) were measured in local streams. Nitrogen content of 0.78% leaf dry mass and a phenolic content of 9.2% leaf dry mass in leaves of *Castanea sativa* were also measured by Canhoto (1994).

Experiment 1: food consumption

Feeding rates of *S. vittatum* were measured by randomly allocating 20 specimens (0.81–1.89 mg dry mass) in individual plastic cups containing 200 ml of filtered stream water. To avoid coprofagy, animals were separated from the bottom by a 0.7 mm mesh (Graça et al., 1993). Food was offered in the form of 9 mm diameter leaf discs obtained with a cork borer from *Castanea sativa* leaves conditioned in a local stream for 3 weeks. Leaf discs were individually fixed to the bottom with a pin and replaced when nearly 2/3 were consumed. Animals were allowed to feed for 3 weeks. In addition, 10 leaf discs were placed in cups without animals to control for mass change due to factors other than feeding. Aeration was provided with pipette plastic tips connected to an air pump. Consumption was calculated as the difference between the initial and final leaf dry mass (mg), after correcting for mass changes due factors other than feeding and divided by the elapsed time and the dry mass of experimental animals (see below). The dry mass of leaf discs was obtained after drying the disks for 24 h at 60 °C.

Experiment 2: the influence of photoperiod in the activity and metabolism

According to the literature, several Trichoptera species are more active at night than during the day (Elliot, 1969, 1970). The congeneric *S. personatum* feeds preferentially during the night which is also the period of higher activity (Wagner, 1990). To test whether the same occurs with *S. vittatum*, animals moving (crawling or interacting) in darkness and light periods were counted (Experiment 2a) and their respiratory rates in the same periods were measured (Experiment 2b).

To measure activity (Experiment 2a), 23 animals were distributed in three experimental boxes (7 + 8 + 8) with aerated filtered stream water. No sand or food were provided. At 10 min intervals (n=7 during the day and n=7 during the night), the number of animals moving in each box was counted. An average of active animals in each observation was computed. The room artificial light was set to a day/light phase of 12/12 h. 'Night' measurements were done with the help of a soft non-direct light, which was off between observations.

To measure respiration rates (as an indicator of metabolism; Experiment 2b), 10 animals (2.9–10.6 mg dry mass) were individually placed in 8 ml chambers (glass syringes), closed in the top by rubber cork and opened at the end. A capillary tube inserted through the cork, provided oxygen saturated water to the chambers via a peristaltic pump (flow, **F**, between 5 and 8 ml h^{-1}). The difference between the oxygen of incoming water (**O_2i**) and the oxygen of the outgoing water (**O_2o**) is attributed to the respiration of the speciemens. A syringe without animals was used as a control (Graça, 1990). The water leaving the chambers was collected with a micro-syringe, injected into a micro-camera coupled to an oxygen electrode, connected to an oxymeter.

Respiration rates for each experimental animal were measured 5 times during the dark and 5 times during the light periods. At the end of the experiment, the anterior opening of the caddis case (**Lc**) was measured in order to determine their dry mass (**Dwa**) according to the expression (Canhoto, 1994):

$$\mathbf{lnDwa} = (\mathbf{Lc} - \mathbf{1.664})/\mathbf{0.599}$$

Respiratory rates (**RR**) were given by the expression:

$$\mathbf{RR} = [(\mathbf{O_2i} - \mathbf{O_2o}) \times \mathbf{F}]/\mathbf{Dwa}$$

A mean respiratory rate of animal was calculated for the dark and light periods.

Experiment 3: changes in growth during development

The aim of this experiment was to investigate how growth rates of larvae change during development. Animals were allocated in three size classes, according to their mass: small (0.8–3.7 mg; n=5), medium (3.8–10.5 mg; n=7) and large (10.6–22.8 mg; n=5). Specimens were measured to obtain their initial dry weight (**Dwi**) and individually placed in experimental boxes

containing conditioned (3 weeks) leaves of *Castanea sativa*. Animals were allowed to feed for 21 days after which they were measured again (**Dwf**) and their daily growth rates (**DGR**) obtained through the expression:

$$\mathbf{DGR} = (\mathbf{Dwi} - \mathbf{Dwf})/\mathbf{t}$$

The specific growth rate was given by the expression:

$$\mathbf{SDGR} = (\mathbf{DGR}/\mathbf{Dwi}) \times \mathbf{100}$$

Experiment 4: importance of faeces as food item

Coprofagy is known to occur in some detritivorous (e.g. *Asellus aquaticus*; Rossi & Vitaglio-Tadini, 1978). Our own observations confirmed that this was also the case for *S. vittatum*. We therefore evaluate the role of faeces as a food source for this species, measuring growth in sets of animals feeding on leaves and animals feeding on faeces collected from other individuals. The procedure concerning animals size classes, number of animals, exposure time and mathematical calculations, described to the previous experiment, was reproduced here.

Results

Specimens of *S. vittatum* with a size range between 0.81 and 1.89 mg dry mass consumed conditioned leaves of *Castanea sativa* at a rate of 0.47 mg leaf dry mass mg animal^{-1} d^{-1}.

The number of active animals during the day was significantly lower than during the night (*t*-test: t=8.182, df=12, $p<0.001$; Figure 1). Accordingly, the same was observed with respiration: nocturnal respiratory rates for every individual were higher than diurnal respiratory rates (day: 0.46–2.91 μg O_2 h^{-1} mg animal^{-1}, night: 0.95–4.49 μg O_2 h^{-1} mg animal^{-1}; paired *t*-test: t=5.558, df=6, $p<0.001$; Figure 2).

Size significantly affected daily growth rates (ANOVA: F=4.921, df=2, $p<0.05$; Figure 3). However, only animals of small size grew at lower rates (0.02 mg d^{-1}) (Tukey test, $p<0.05$). In terms of specific growth (growth/individual mass) those who had a faster daily growth rate were medium size larvae (4.8%; Figure 4). Daily growth rates of animals fed with *Castanea sativa* leaves were compared, within the same size class, with growth rates of animals fed with faeces. The replacement of leaves by faeces resulted in a significant reduction of growth in the medium size class group (66% reduction; paired *t*-test t=2.63, df=12,

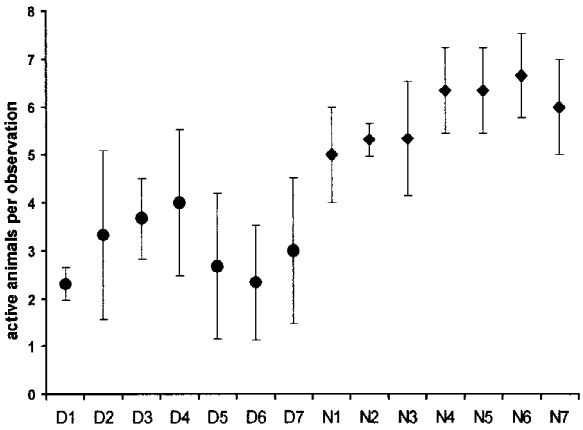

Figure 1. Variation in the number of active animals during 'day' (D1–D7) and 'night' (N1–N7) periods, measured at 10 min intervals (mean±s.e.). Artificial light matched the natural fotoperiod during the experimental test; lights were off at 21h.

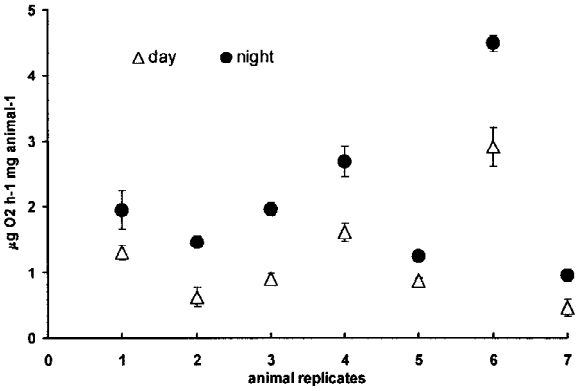

Figure 2. Mean nocturnal and diurnal respiratory rates (mean±s.e.; n=10) per experimental *S. vittatum*.

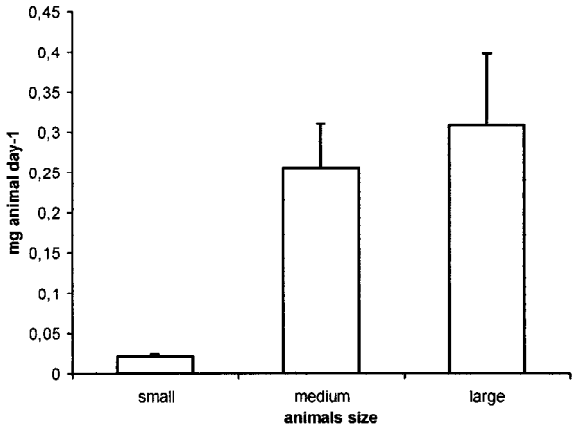

Figure 3. Daily growth rates of three size groups of *S. vittatum* individuals (mean+s.e.). Small = 0.8—3.7 mg; medium = 3.8–10.5 mg; large = 10.6–22.8 mg.

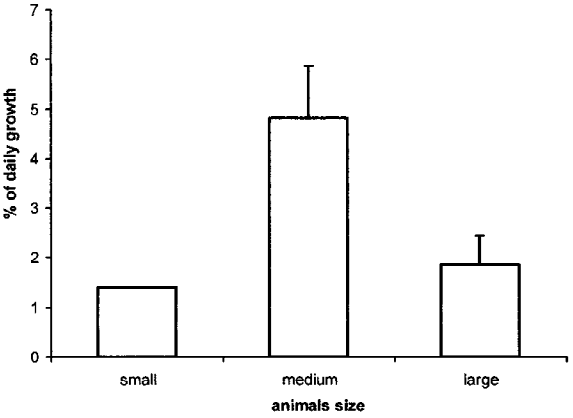

Figure 4. Daily specific growth rates of three size groups of *S. vittatum* individuals (mean+s.e.). Small = 0.8–3.7 mg; medium = 3.8–10.5 mg; large = 10.6–22.8 mg.

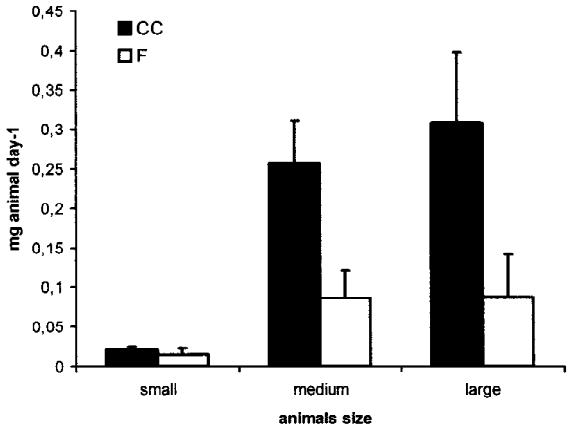

Figure 5. Daily growth rates of three size classes of *S. vittatum* fed with *Castanea sativa* leaves (CC) or faeces (F) (mean+s.e.). Small=0.8–3.7 mg; medium =3.8–10.5 mg; large =10.6–22.8 mg.

$p<0.01$). For large size class animals, the reduction in growth was higher (72%), but the differences where not significant (t=2.10, d.f.=8, p=0.07).

For small animals, the switching from leaves to faeces had no significant effect on growth (t=0.78, df=6, p=0.50) (Figure 5).

Discussion

The mean daily consumption here reported (at 15 °C) was 0.47 mg leaf dry mass mg animal^{-1} d^{-1}, (=0.522 mg leaf dry mass animal^{-1} d^{-1}). This value was below of the previously reported for *S. personatum*: 1.77 mg leaf dry mass animal^{-1} d^{-1} at 10 °C (Wagner, 1990) or 1.2 mg leaf dry mass animal^{-1} d^{-1}at 13 ° C (Iversen, 1979). However, the animals we used were small. Our animals had a dry mass ranging from 0.5 to 3.7 mg, compared with a maximum of 22.8 mg found in our samples. A maximum of 20.0 mg animals dry mass was reported by Iversen (1979).

Densities of *S. vittatum* at S. João stream ranged from 3 (January) to 96 (September) ind. m^{-2} (Carvalho, Coimbra & Graça, unpublished). If we assume a mean density of 25 ind. m^{-2} and a mean annual temperature of 15 ° C (unpublished data), we calculate that this species alone have the capacity to fragment 32 mg AFDW of leaves m^{-2} daily. This correspond to nearly 12 g AFDW of leaves m^{-2} y^{-1}. This value is lower than the 50g AFDW of leaves m^{-2} calculated by Iversen for two streams in Denmark for the congeneric *S. personatum* (1980). Although no leaf input measurements were done at the study site, Abelho & Graça (1998) measured in the nearby chestnut forest 'Mata da Margaraça' an annual litter production of 715 g AFDW m^{-2}.

The observed higher night activity and respiratory rates strongly suggests that *Sericostoma vittatum* is a nocturnal detritivore. This is not surprising since the same observation was already verified for other cadisflies such as *Sericostoma personatum*, *Drusus annulatus* and *Odontocerum albicorne* (Elliot, 1969; Wagner, 1990). Those studies showed large displacements of caddisflies (considering their size) and movements to surface rocks or to the vegetation to feed during the night. Probably this nocturnal behaviour mechanism to avoid the interspecific pressure from day-active shredders as well as a predator avoidance mechanism. Wagner (1990) suggests that although higher summer temperatures may enhance food consumption, this differential dial activity may limit food consumption of Sericostomatids during the shorter summer nights.

The measured diurnal respiratory rates of 0.532 μg O_2 h^{-1} mg animal^{-1} (=0.642 μg O_2 h^{-1} animal^{-1}) is in the range of the observed for other benthic detrivores of similar size: 5 μg O_2 h^{-1} animal^{-1} for *Sericostoma personatum* (Iversen, 1979); 0.448 μg O_2 h^{-1} mg animal^{-1} for *Asellus aquaticus* (Prus, 1971) and 1.417 μg O_2 h^{-1} mg animal^{-1} for *Lepidostoma quercina* (Grafius & Anderson, 1979).

In terms of growth the values were also similar those reported for other invertebrates feeding on detritus: 0.31 mg d^{-1} in the present study, and 0.28 mg d-^{1} for *Hesperophylax magnus* and 0.10 mg d^{-1} for *Psychoglypha* sp, two caddisflies (Arsuffi & Suberkropp, 1986).

If we accept that conditioned leaves, in opposition to unconditioned ones, are a high quality food source

for stream detritivores (Suberkropp, 1992; Graça et al., 1993), faeces resulted to be an equally high quality food resource for small specimens of *Sericostoma vittatum*. This would not be expected if we consider that this material already passed through the gut where some nutrients were already taken. However, faeces from *S. vittatum* are plant material which has been pierced into fine particles, easier to ingest by small individuals with mouth parts still poorly developed. On the other hand, the partial digestion of the leaf material in the faeces and the small size of faecal pellets, may enhance bacterial colonisation which, in turn, increases the quality of the faeces as a food resource. This is consistent with the findings by Rossi & Vitaglio-Tadini (1978) that the presence of adult faeces significantly increased the survival, food intake and growth of juvenile *Asellus aquaticus*.

In our experiments, growth of larger size animals was little affected by the replacement of leaves for faeces. This is difficult to explain and may be due to experimental conditions (high variability and small sample size).

The trophic ecology of *S. vittatum* seems to be remarkably similar to the reported for the European congeneric *S. personatum*. Given that *S. personatum* is absent from the Iberian Peninsula, it is plausible that its ecological niche in the detritivorous guild may be occupied by the endemic *S. vittatum* in some sections of the Ribeira de S. João. *S. vittatum* followed by *Tipula* spp are the only shredders present all year around. More research is being done in order to assess the importance of this single species on the leaf fragmentation in streams from central Portugal.

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